From:	SEEDS Joshua <SEEDS.Joshua@deq.state.or.us>
Sent:	Wednesday, June 11, 2014 6:00 PM
To:	Wu, Jennifer; Henning, Alan; Leinenbach, Peter; jeffrey.lockwood@noaa.gov
Cc:	FOSTER Eugene P
Subject:	Draft presentation
Attachments:	DEQ ODFW Joint Presentation PCW & Fish EQC Meeting June 2014_draft.pptx

Here is the draft presentation as it is currently. The Mid Coast TMDL and comparison of states at the end needs doing and overall it needs to be shortened, but you get the idea. This should help with knowing what DEQ and ODFW are covering.

Thanks,
Josh

Joshua Seeds
Nonpoint Source Pollution Analyst
Drinking Water Protection Program
Oregon Department of Environmental Quality
811 SW 6th Ave.
Portland, OR 97204
Phone: 503-229-5081 Fax: 503-229-6037
Email: seeds.joshua@deq.state.or.us

Stream Temperature Science, WQ Temperature Standard & TMDLs, and Riparian Management in Forestlands

Informational Item: Environmental Quality Commission Meeting
June 19, 2014

Gene Foster & Josh Seeds: DEQ
**Bruce McIntosh & Dave Jepsen: ODFW**

Presentation Purpose

- Summary of the factors affecting stream temperatures in Oregon

- The importance of stream temperature for aquatic biota

- The rationale for minimizing anthropogenic warming and restoring and protecting natural thermal regime approach used in the temperature standard (including the Protecting Cold Water Criteria)

- Explain how TMDLs are used as a tool to protect aquatic species & restore natural thermal regimes

- Provide information on the connection between temperature standards & forest practices in Oregon & neighboring states.

Basics of Stream Temperature

- Shade, flow, & channel complexity are important factors that affect stream temperatures within a watershed.

- Climate affects stream temperature.

- Effective shade is the percent of daily solar radiation blocked by vegetation & topography.

Solar$_1$ – Potential daily direct beam solar radiation load adjusted for julian day, solar altitude, solar azimuth and site elevation.
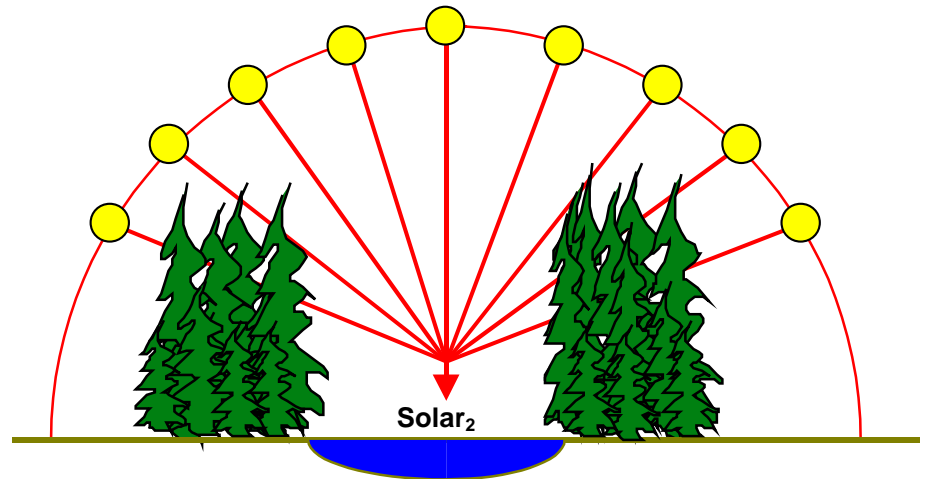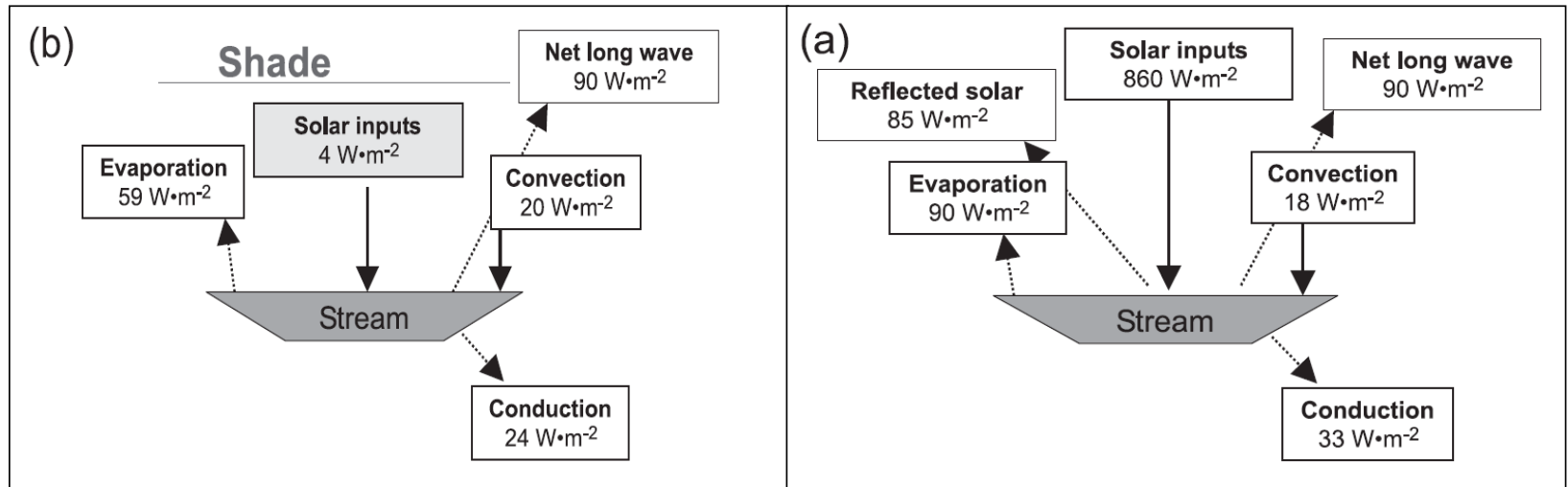
Solar$_2$

$$\text{Effective Shade} = \frac{(\text{Solar}_1 - \text{Solar}_2)}{\text{Solar}_1}$$

Where,
   Solar$_1$: Potential Daily Direct Beam Solar Radiation Load
   Solar$_2$: Daily Direct Beam Solar Radiation Load Received at the Stream Surface

Basics of Stream Temperature

Heat energy fluxes at noon on July 20, 1997 on a **fully shaded** study stream in the H.J. Andrews Experimental Forest. **Heat energy lost is -149 W*m^{-2}.**

Heat energy fluxes at noon on July 20, 1997 on an **unshaded** study stream in the H.J. Andrews Experimental Forest. **Heat energy gained is 580 W*m^{-2}.**

Johnson 2004

- Solar energy drives temperature on smaller streams.

- Streams more easily absorb thermal energy from sunlight than lose it once absorbed.
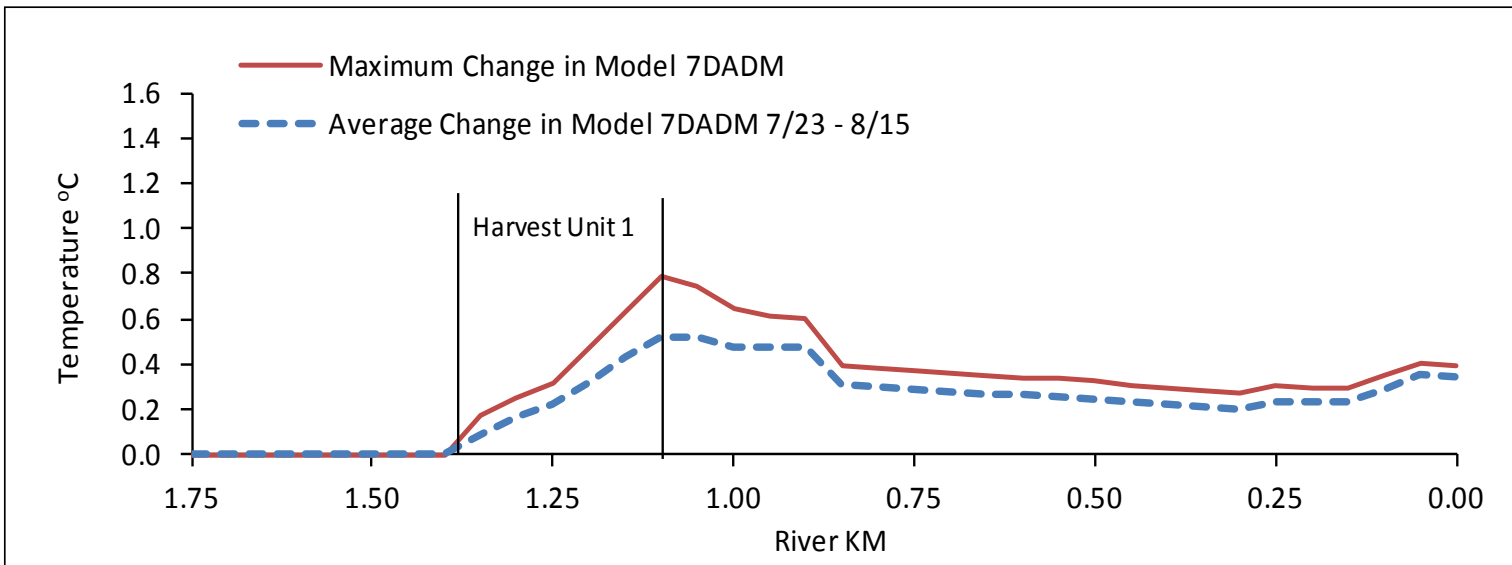
Heat Source Results for Argue Creek
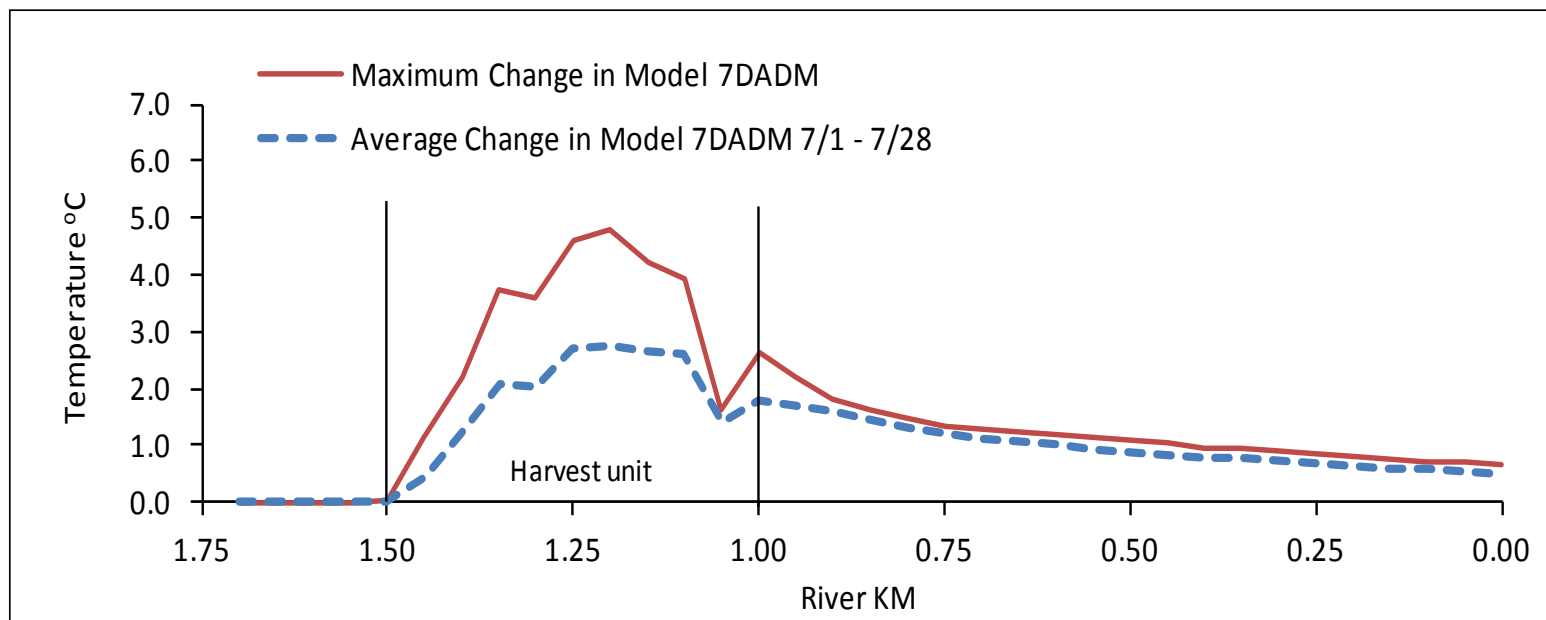
Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 7854, holding all factors constant except vegetation.

- Since gain is more efficient than loss, thermal energy can be transported downstream.

Heat Source Results for Drift Creek Trib

Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 5556, holding all factors constant except vegetation.

Results only include effect of the Harvest Unit 1 in RipStream study area.

- Dilution of thermal energy is not the same as dissipation.
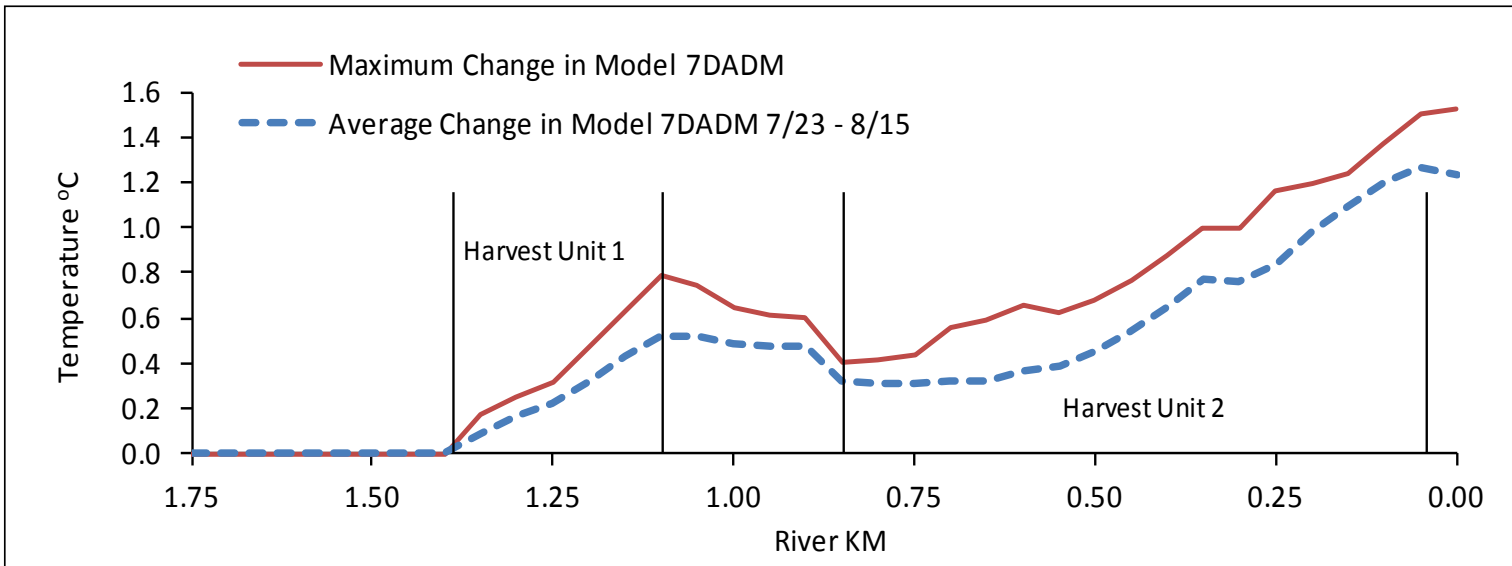
Heat Source Results for Drift Creek Trib

Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 5556, holding all factors constant except vegetation.

Results include effects from the harvest unit in RipStream study area (Harvest Unit 1) and a second harvest unit downstream of the study area (Harvest Unit 2).

- Multiple disturbances & human activities can result in cumulative effects, even with undisturbed reaches present.

Stream Temperature & Aquatic Life

- Stream temperature determines the rate at which processes occur.

- Natural thermal regimes provide the best conditions for fish & other native aquatic life.

- Temperature effects typically occur on a continuum. Increases above natural thermal potential:

  - Increase risk to fish,

  - Can have negative effects on salmonid populations, particularly when occurring across the landscape (McCullough 1999, US EPA 2001).

- Thermal diversity is necessary at multiple scales.

Thermal heterogeneity *is* habitat complexity

- Natural Thermal Regimes (NTR) are dynamic and promote **biological diversity**

  - A NTR includes magnitude, frequency, duration, timing, and rate of change (Olden and Naiman 2010). It does not imply constancy.

  - Landscape conversion alters the mean *and* variance of stream temperatures (Steel et al. 2012).

NTRs & Biological Diversity

- Fish life history chronologies are mediated by predictable thermal variability (seasonality).

- Homing of salmonids promotes reproductive isolation, allowing natural selective forces like NTR to operate on heritable phenotypic traits, resulting in distinct, locally adapted populations (Hillborn et al. 2003).

NTRs & Biological Diversity

- Spatial variation in water temperature is linked to:
  - Population differentiation & differences in spawn timing in salmon
  - Ecologically important divergence in salmon at the within-stream scale
  - Salmonid subsidies (food pulses) that support within-network foraging movement & diversity of resident predators (Ruff et al. 2011).

NTRs & Biological Diversity

- Dampening the natural thermal variability & the temporal sequence of the natural thermal regime:
  - Reduces intraspecific diversity by reducing opportunities for local adaptation and genetic variation among populations or phenotypic variation within populations (Watters et al. 2003), and therefore, salmonid species diversity in Oregon.
  - Reduces population and meta-population (ESU) resilience, since diversity confers stability in fish population dynamics (production cycles).

EPA-6822_000026

Thermal heterogeneity *is* habitat complexity

- Thermal diversity in a stream network promotes aquatic **biological productivity**
  - Fish are less adapted to mean of water temperatures than to variability (diversity).
    - Fish can detect & exploit thermal heterogeneity to avoid heat stress, & meet metabolic and reproductive requirements (Hodgson and Quinn 1991, Torgersen et al. 2012).
    - Fish exploit thermal heterogeneity not only to survive, but thrive.

Thermal Diversity & Biological Productivity

- Under non-stressful temperatures, coho exploiting thermal heterogeneity grew at faster rates than individuals with other behaviors (Armstrong et al. 2013).

- Natural Thermal Regimes:
  - Directly influence metabolic rates, physiology, & life-history traits of aquatic ectotherms (Holtby et al.),
  - Help determine rates of important ecological processes such as nutrient cycling & productivity, and
  - Indirectly mediate biotic interactions (references in Olden and Naiman 2010).

Thermal Diversity & Biological Productivity

- Salmonid species with colder thermal requirements (ESA-listed bull trout) are confined to "cold-water refuges".
  - If these refuges become warmer, bull trout habitat will shrink, due to competitive disadvantage with other salmonid species.
- Thermal refuges below the species-specific BBNC also buffer other cool/cold water adapted species from predation by invasive warm water predators

Thermal Diversity & Biological Productivity

- With acute reach and segment scale temperatures, the only biological response is moving to habitat with sub-lethal temperatures.
  - A prerequisite for success of this stress-avoidance strategy is the presence of "stepping stone" reaches or patches that contain cooler water.

- In warm streams, thermal refuge patches provide opportunities for fish to thermoregulate (Ebersole et al. 2003)
  - A spatially distributed network of habitats with cooler temperatures allows a fish population to utilize a larger portion of a stream network, thereby reducing mortality.

Disturbance on the Landscape

•Riparian areas in higher reaches burn as often as upland forest.

•Riparian areas in lower reaches burn less often than upland forest.

•Current disturbance regime is different than historic regime.

  •About 10 years for thermal recovery after disturbance.

  •Pre-settlement 2.4-6.7% of landscape in thermal recovery (Agee 1990, Wimberly 2002).

  •Fire return intervals in western Oregon range from 100-400yrs, 200yrs is typical (Morrison & Swanson 1990, Wimberly 2002).

  •With an even 40yr harvest rotation, 25% of landscape would be in thermal recovery at any time.

Disturbance on the Landscape

•Change detection analysis of LandSat data (1985-2009) in the Mid Coast Basin shows area in thermal recovery for 1994-2008.

South Fork Siletz River 2006
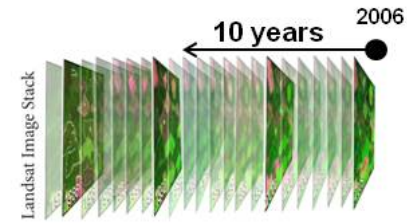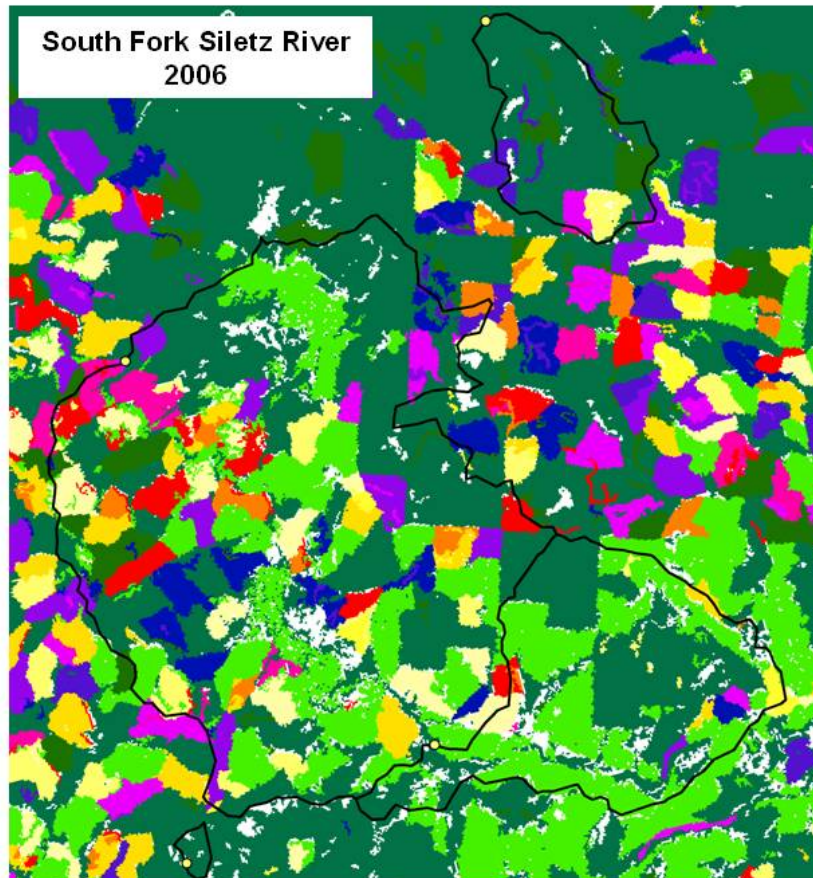
10 years 2006
Landsat Image Stack
Kennedy et al 2010.

Percent area disturbed in 2006 = 17%

Includes any harvest 10 years prior from 1996-2006.

Color = harvested 1996 - 2006

White = Non forested (Ag/Rural residential, meadow)

Dark Green = not harvested 1985 - 2006.

Light Green = harvested 1985-1996. (Not counted in total)

Disturbance on the Landscape

- Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.

- Middle Siletz River watershed private industrial forestland riparian area in thermal recovery:
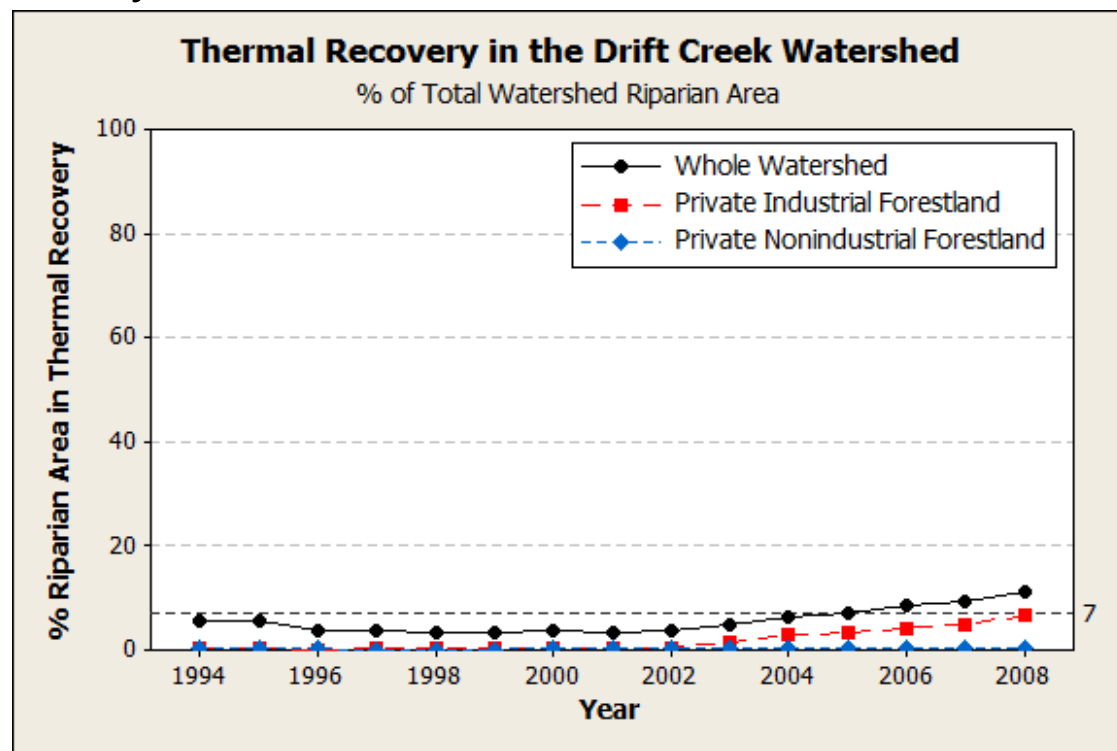
- Maximum in 2008: 36.7%

- Minimum in 1994: 14.1%
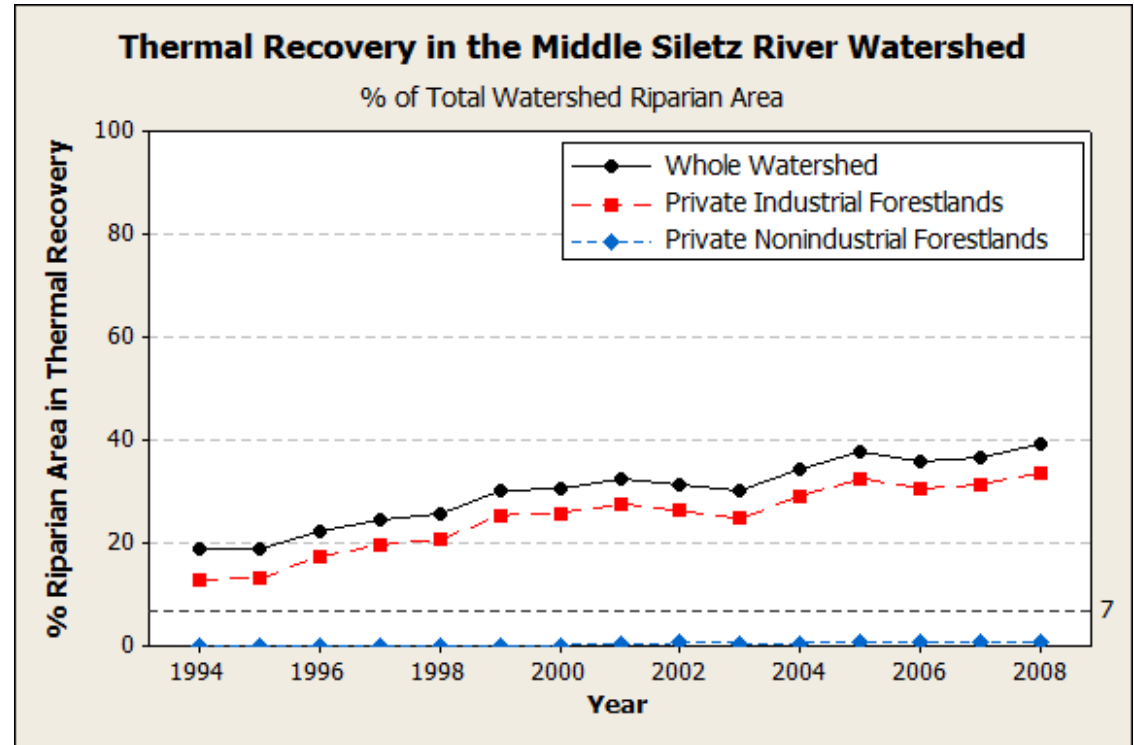
Thermal Recovery in the Middle Siletz River Watershed

% of Total Watershed Riparian Area

Disturbance on the Landscape

•Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.

•Drift Creek watershed private industrial forestland riparian area in thermal recovery:

•Maximum in 2008: 25.8%

•Minimum in 1996: 0.2%

Thermal Recovery in the Drift Creek Watershed
% of Total Watershed Riparian Area

EPA-6822_000034

Disturbance on the Landscape

•Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.

•Lake Creek watershed private industrial forestland riparian area in thermal recovery:

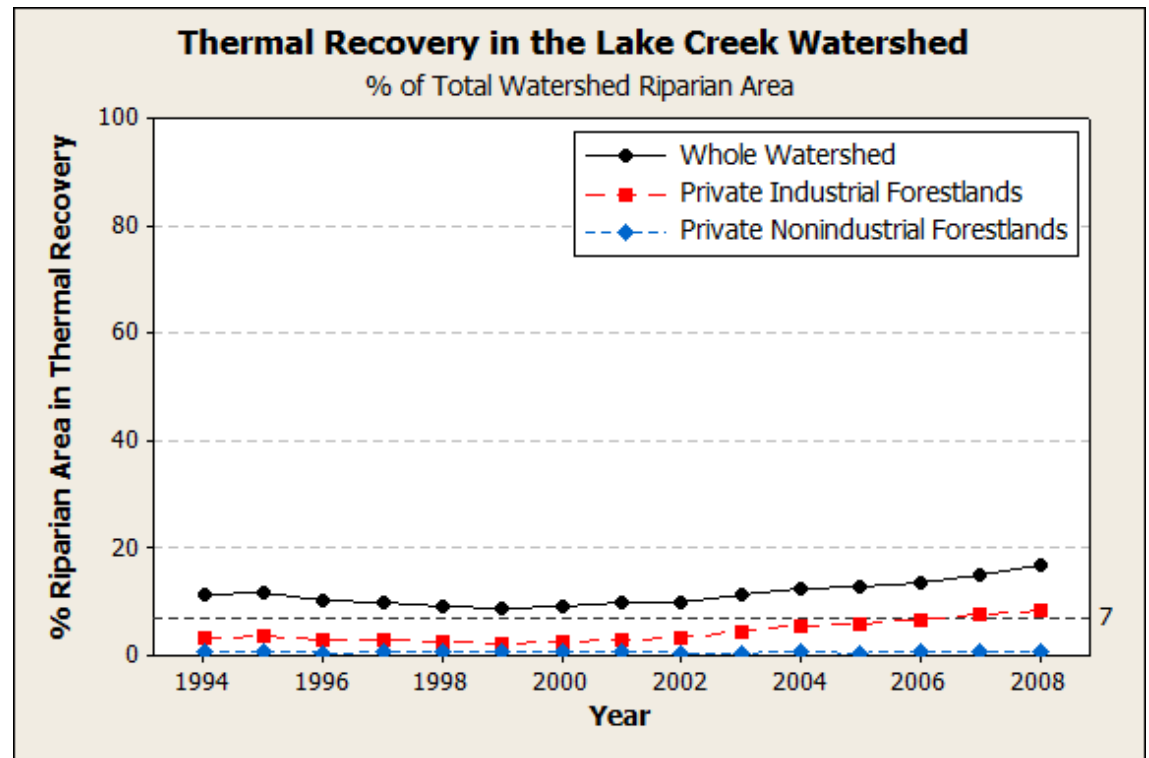•Maximum in 2008: 34.5%

•Minimum in 1999: 9.7%

Thermal Recovery in the Lake Creek Watershed
% of Total Watershed Riparian Area

Relevant Oregon Water Quality Standards

- Temperature Standard: Maintain & restore natural thermal regimes across landscape for all aquatic species
  - Biologically-Based Numeric Criteria (BBNC; OAR 340-041-0028(4))
  - Protecting Cold Water criterion (PCW; OAR 340-041-0028(11))
  - Human Use Allowance (HUA; OAR 340-041-0028(12)(b))
  - ~~Natural Conditions Criterion~~
- Antidegradation Policy
- Designated Uses
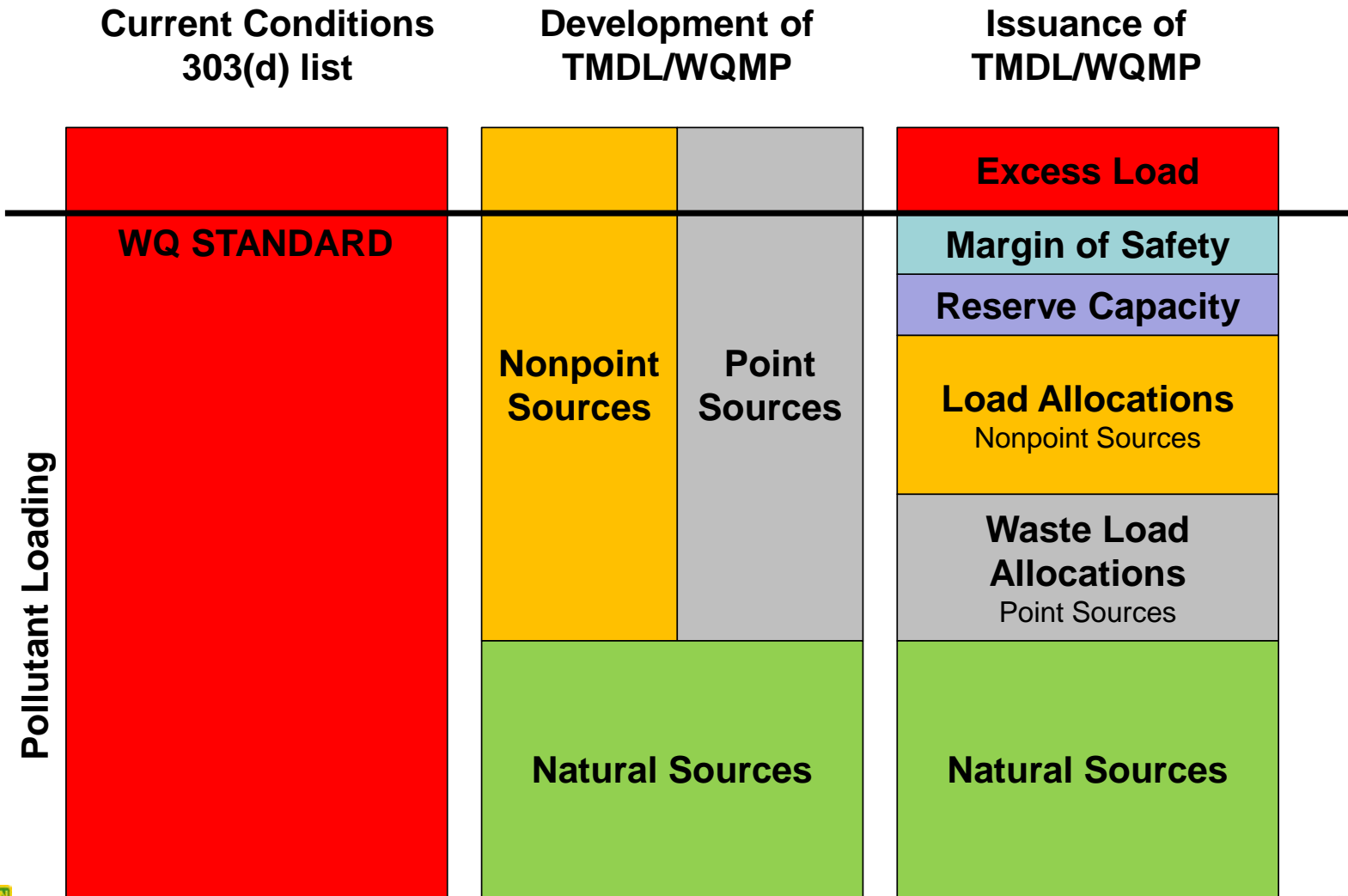
Protecting Cold Water Criterion

- PCW protects the natural thermal regime in waters colder than BBNC.

- Biologically-based numeric criteria are set at the upper end of the optimal range for salmonids.

- There is a need for water colder than the BBNC:

  - Small increases in stream temperature (>0.3°C) result in greater uncertainty about biological/ecological effects.

  - Heating of headwaters reduces the extent of downstream waters at optimal temperatures.

  - Fish often experience multiple stressors.

  - Need capacity to adapt to climate change & yearly variation.

EPA-6822_000037

Temperature
Total Maximum Daily Loads

- TMDLs are a tool to protect aquatic species & restore natural thermal regimes.

    - Human Use Allowance: 0.3°C for all human sources of thermal loading.

    - Human sources are given fractions of the HUA as wasteload allocations (point sources) or load allocations (nonpoint sources).

EPA-6822_000038

TMDL = WLA + LA + NS + MOS + RC

Current Conditions 303(d) list	Development of TMDL/WQMP		Issuance of TMDL/WQMP
			Excess Load
WQ STANDARD	Nonpoint Sources	Point Sources	Margin of Safety
			Reserve Capacity
			Load Allocations Nonpoint Sources
			Waste Load Allocations Point Sources
	Natural Sources		Natural Sources

Pollutant Loading

25

Temperature
Total Maximum Daily Loads

- TMDLs are a tool to protect aquatic species & restore natural thermal regimes by addressing human sources of thermal loads.

  - Human Use Allowance: 0.3°C for all human sources of thermal loading.

  - Human sources are given fractions of the HUA as wasteload allocations (point sources) or load allocations (nonpoint sources).

Temperature Total Maximum Daily Loads

- In the Willamette River TMDL, wasteload allocations are very small for point sources.

- The WLA for Wilsonville's sewage treatment is 0.0029°C (39 million kcal/day at summer 7Q10 flow)

  - Spending $?? On cooling tower to meet WLA

Map 4.4   303(d) Listings for Temperature and monitoring sites

Willamette Basin 303d Temperature Listings

303d Listed Streams:

Temperature

DEQ Ambient Site
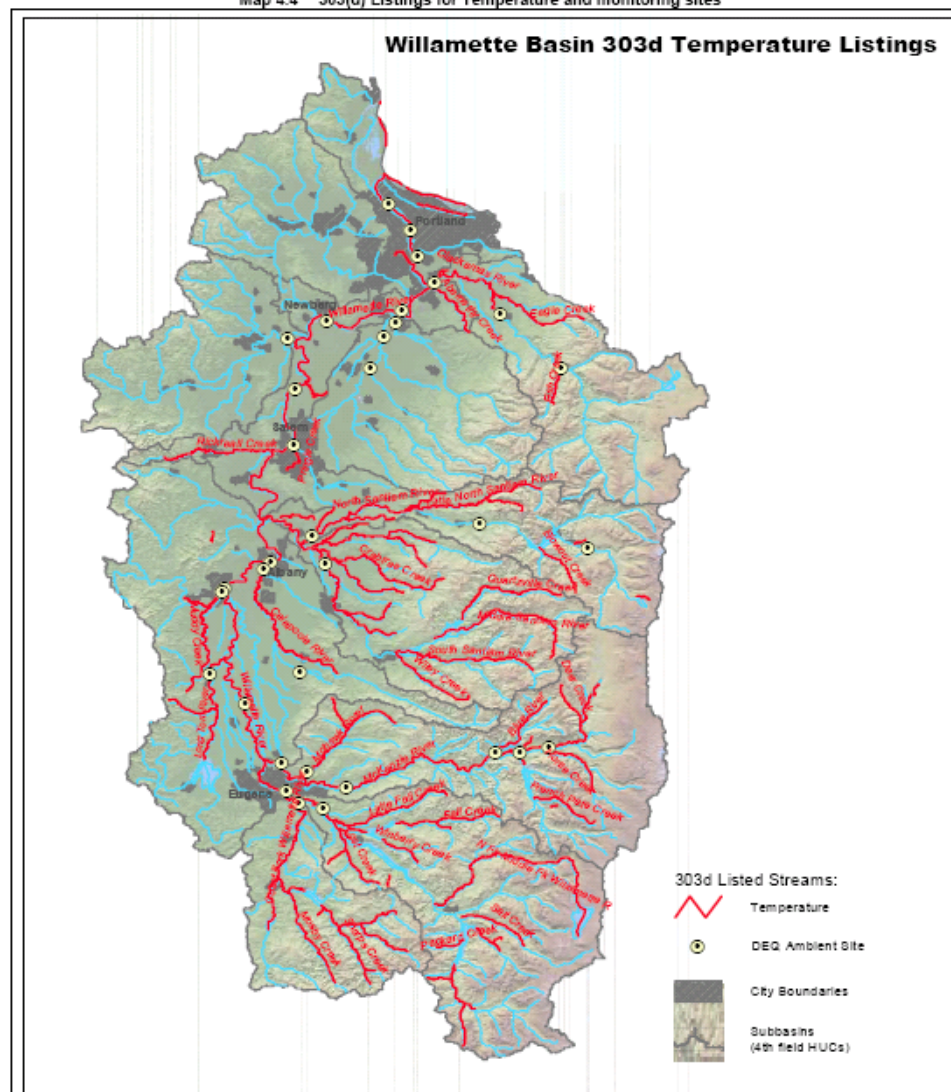
City Boundaries
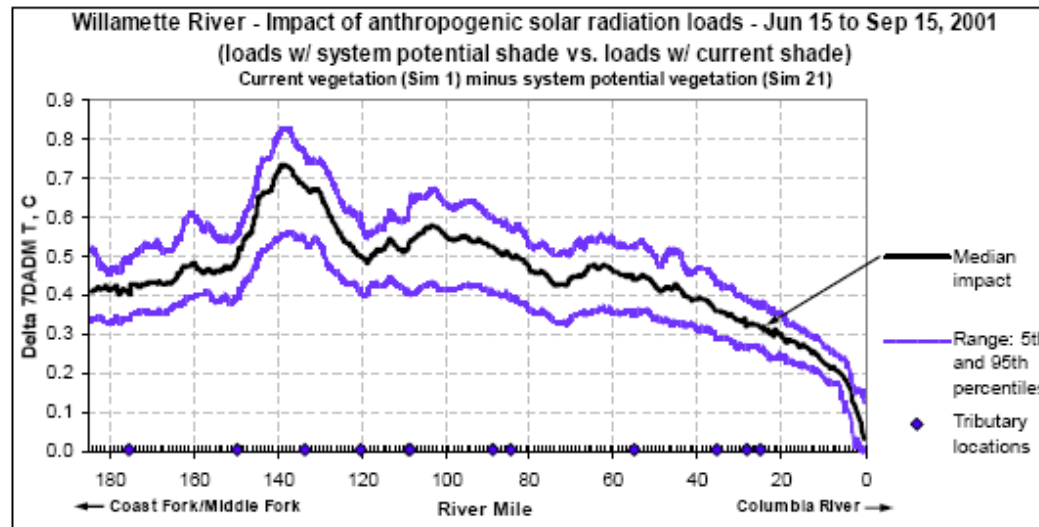
Subbasins (4th field HUCs)

27

Figure 4.14   Maximum difference in seven day average of the daily maximum temperatures between 2001 calibrated model and 2001 calibrated model with system potential vegetation.
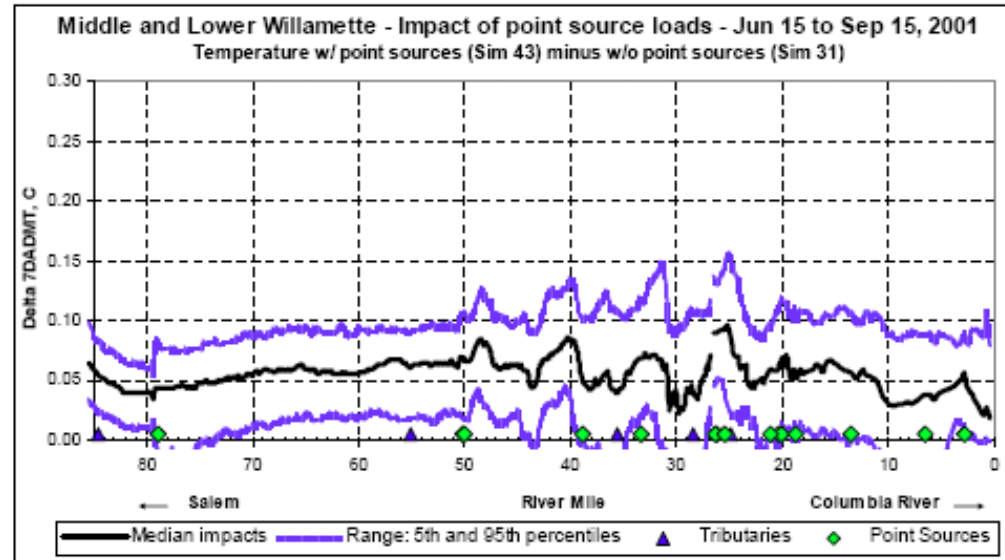

Nonpoint Source Impacts = Tenths of degrees

Point Source Impacts = Hundredths of degrees

Figure 4.9   Current point source load effects on temperatures during late spring and summer 2001.

Lack of shade is a larger source of heat than point sources for the mainstem Willamette

Temperature TMDLs in Western Oregon

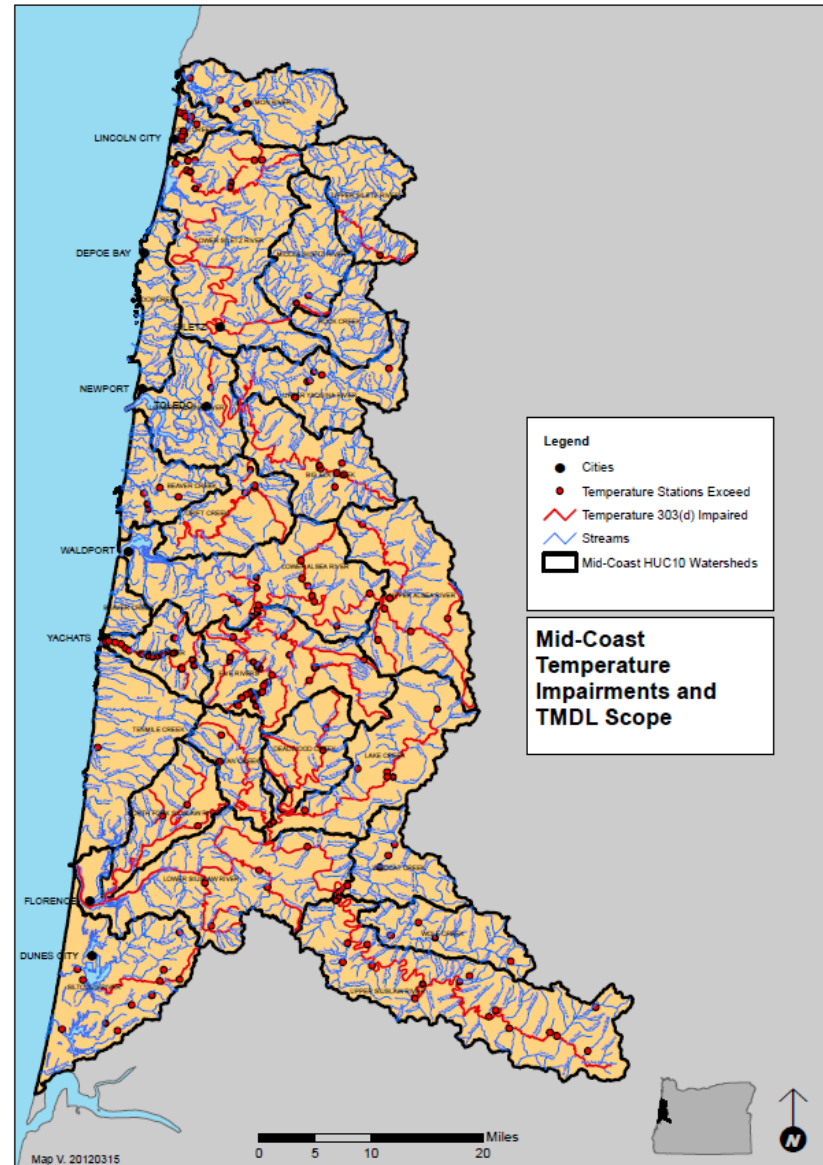•Locations without Temperature TMDLs have 303(d) listings for temperature that require TMDL development.

Load Allocations for Temperature in Western Oregon - HUC

EPA-6822_000043
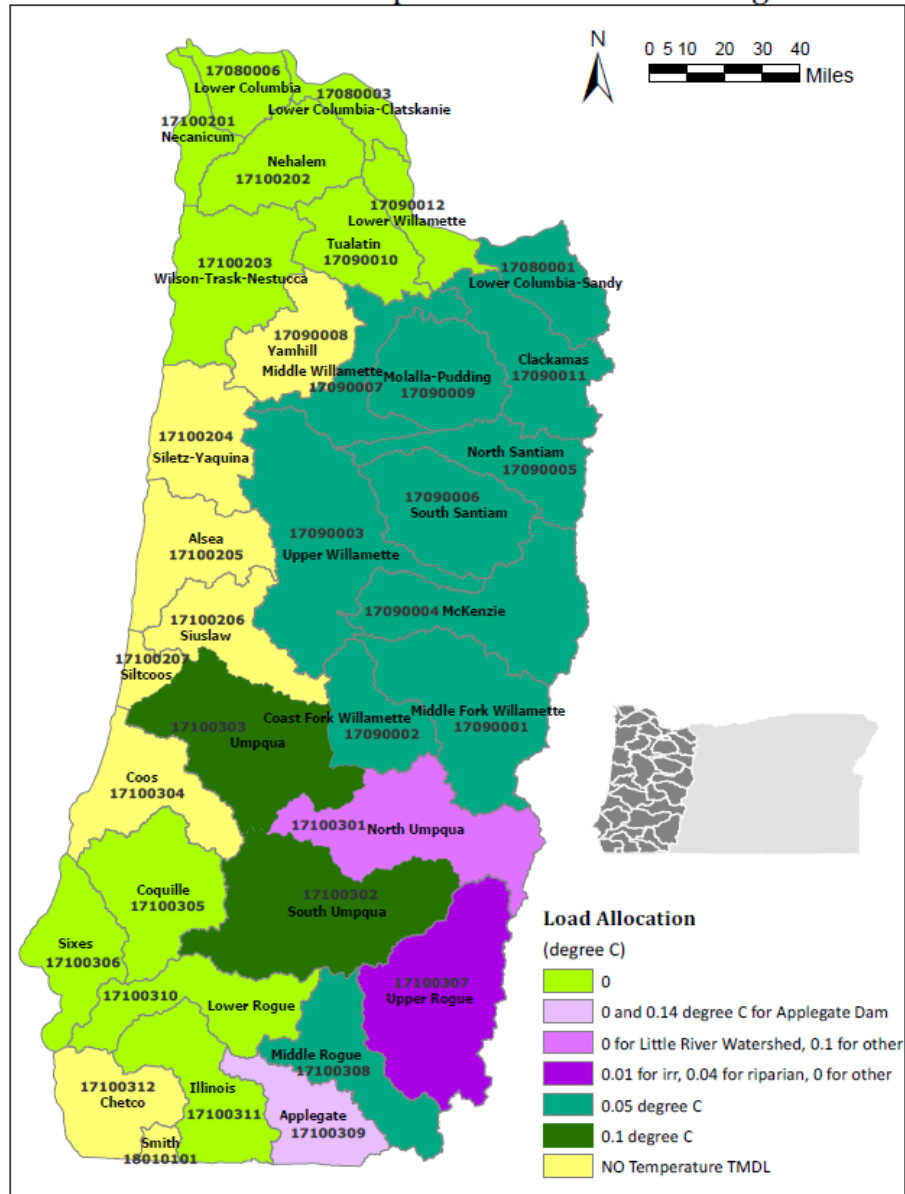
MidCoast Temperature TMDL

Temperature TMDL development methods in the Mid Coast represent

TMDL Development for Temperature Impairments in the MidCoast

- 350+ data stations analyzed (1999 – 2011)
- 200+ stations exceed water quality standards
- 48+ streams identified as impaired - 303(d) list

Legend
- Cities
- Temperature Stations Exceed
- Temperature 303(d) Impaired
- Streams
- Mid-Coast HUC10 Watersheds

Mid-Coast Temperature Impairments and TMDL Scope

Map V. 20120315

Miles
0 5 10 20

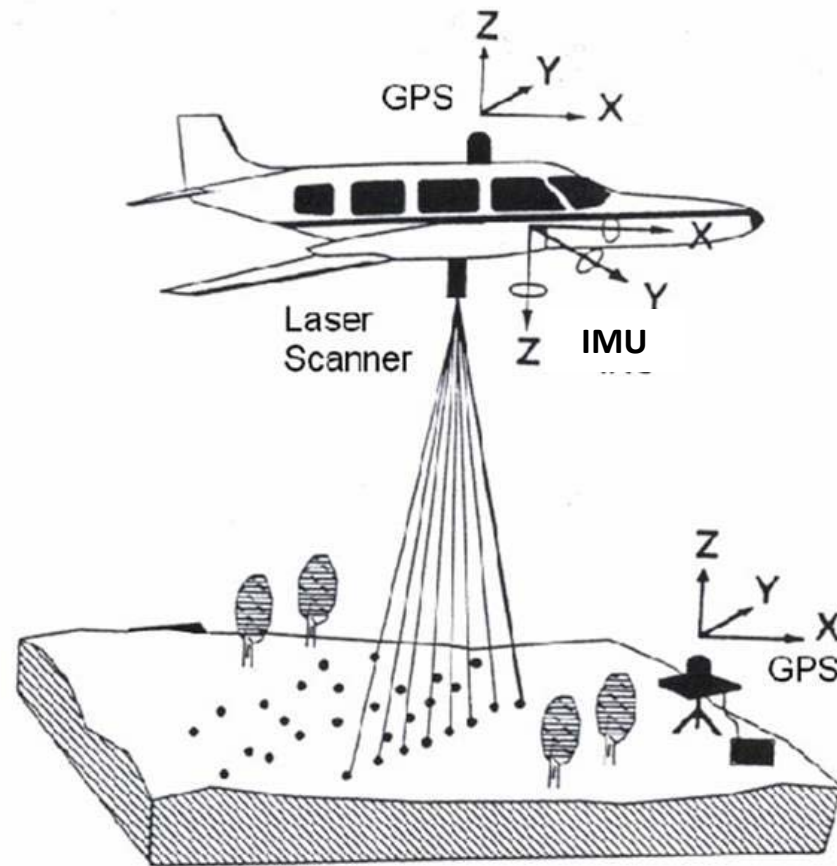# Temperature – Riparian Condition: Historic, Current, and Future Conditions
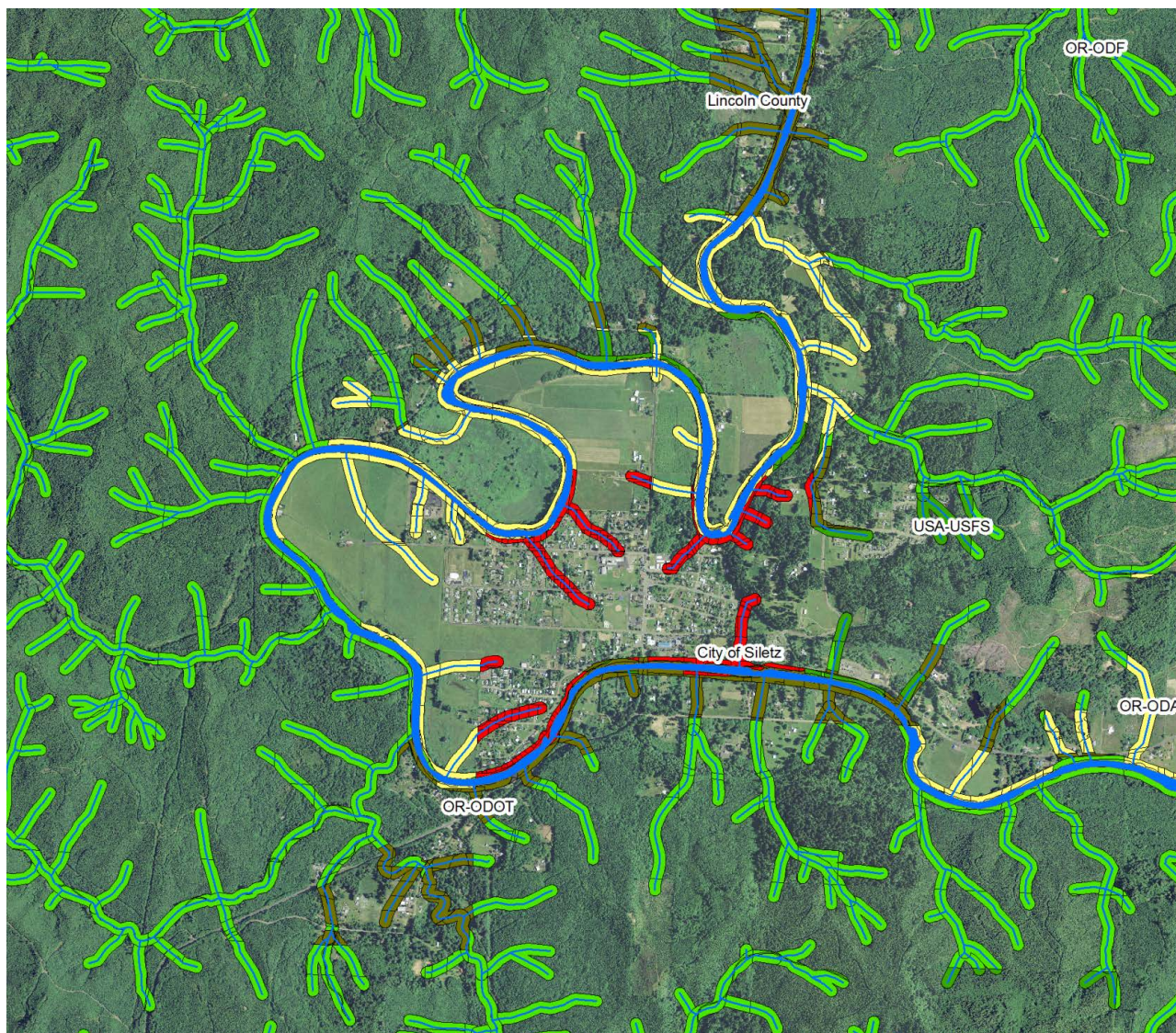
Vegetation Inventory

- Land Cover Classification

- Near Stream Area Delineation

- DMA / Responsible Person Mapping

- Example Results

- Example Prioritization

LiDAR (**L**ight **D**etection and **R**anging)

Near Stream Area DMA / Responsible Persons

OR-ODF

Lincoln County

USA-USFS

City of Siletz

OR-ODA

OR-ODOT

EPA-6822_000048

LiDAR Example: Big Elk Creek Watershed
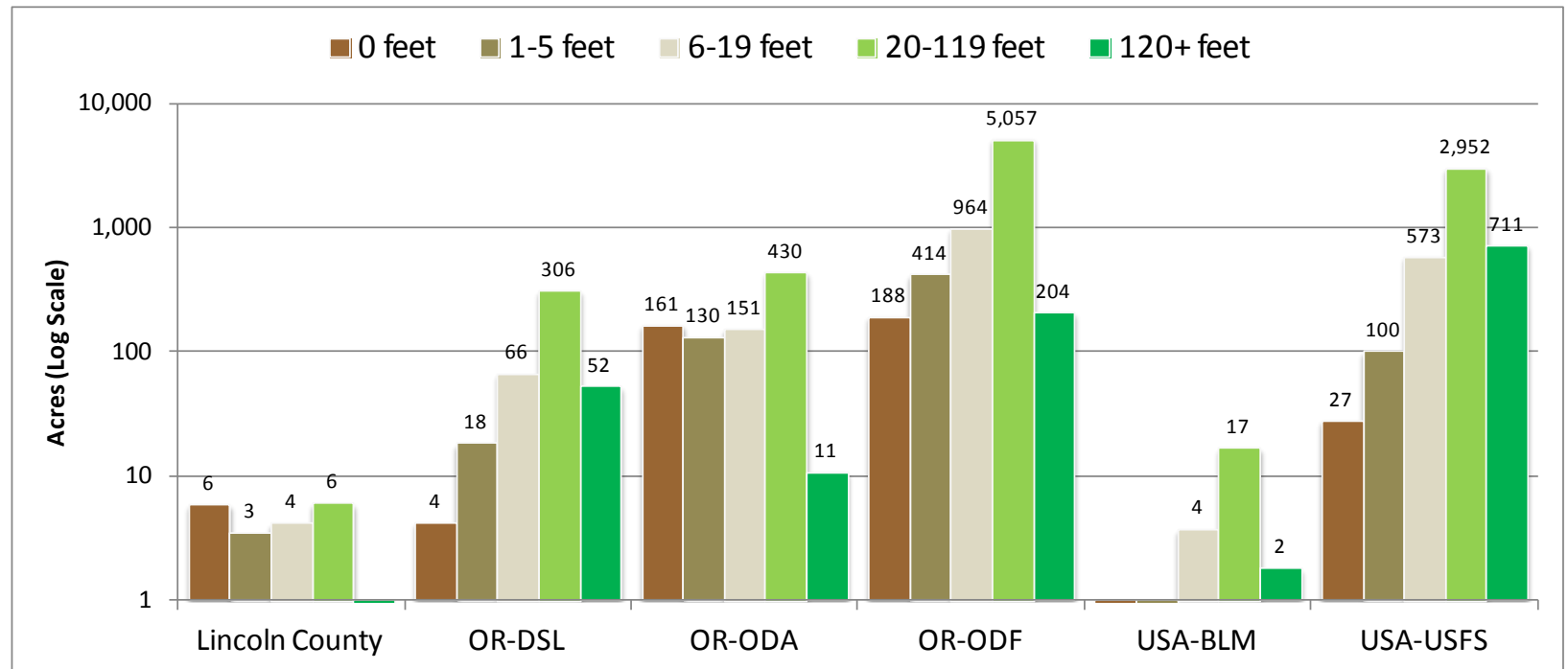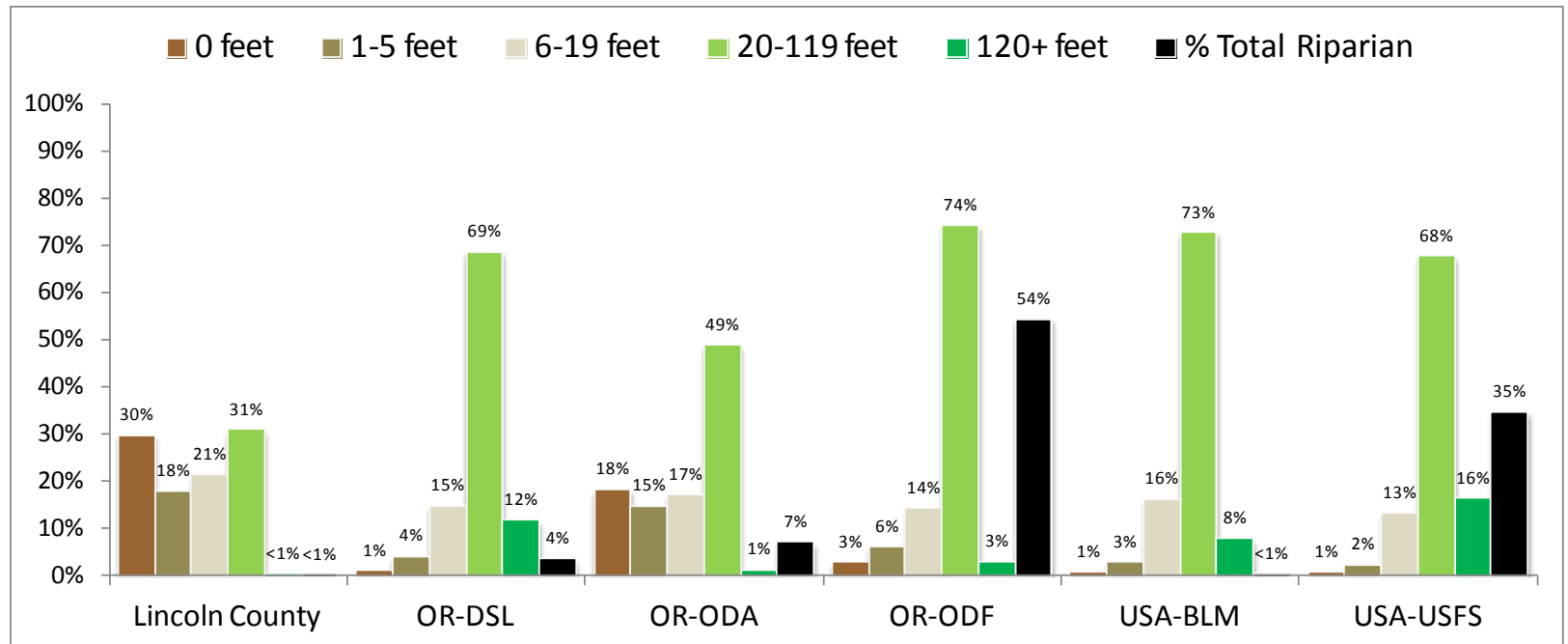
Acres in each LiDAR vegetation height classification within 30 meters of the stream in Big Elk Creek by DMA

Legend: ■ 0 feet ■ 1-5 feet ■ 6-19 feet ■ 20-119 feet ■ 120+ feet

Y-axis: Acres (Log Scale)

Lincoln County: 6, 3, 4, 6
OR-DSL: 4, 18, 66, 306, 52
OR-ODA: 161, 130, 151, 430, 11
OR-ODF: 188, 414, 964, 5,057, 204
USA-BLM: 4, 17, 2
USA-USFS: 27, 100, 573, 2,952, 711

EPA-6822_000050

Percent area in each LiDAR vegetation height classification within 30 meters of the stream for each DMA in the Big Elk watershed

Legend: ■ 0 feet ■ 1-5 feet ■ 6-19 feet ■ 20-119 feet ■ 120+ feet ■ % Total Riparian

Lincoln County: 30%, 18%, 21%, 31%, <1%, <1%
OR-DSL: 1%, 4%, 15%, 69%, 12%, 4%
OR-ODA: 18%, 15%, 17%, 49%, 1%, 7%
OR-ODF: 3%, 6%, 14%, 74%, 3%, 54%
USA-BLM: 1%, 3%, 16%, 73%, 8%, <1%
USA-USFS: 1%, 2%, 13%, 68%, 16%, 35%

Acres in each NLCD vegetation canopy classification within 30 meters of the stream in the Upper Siuslaw River watershed by DMA

Legend: 0% ■ 1%-100%

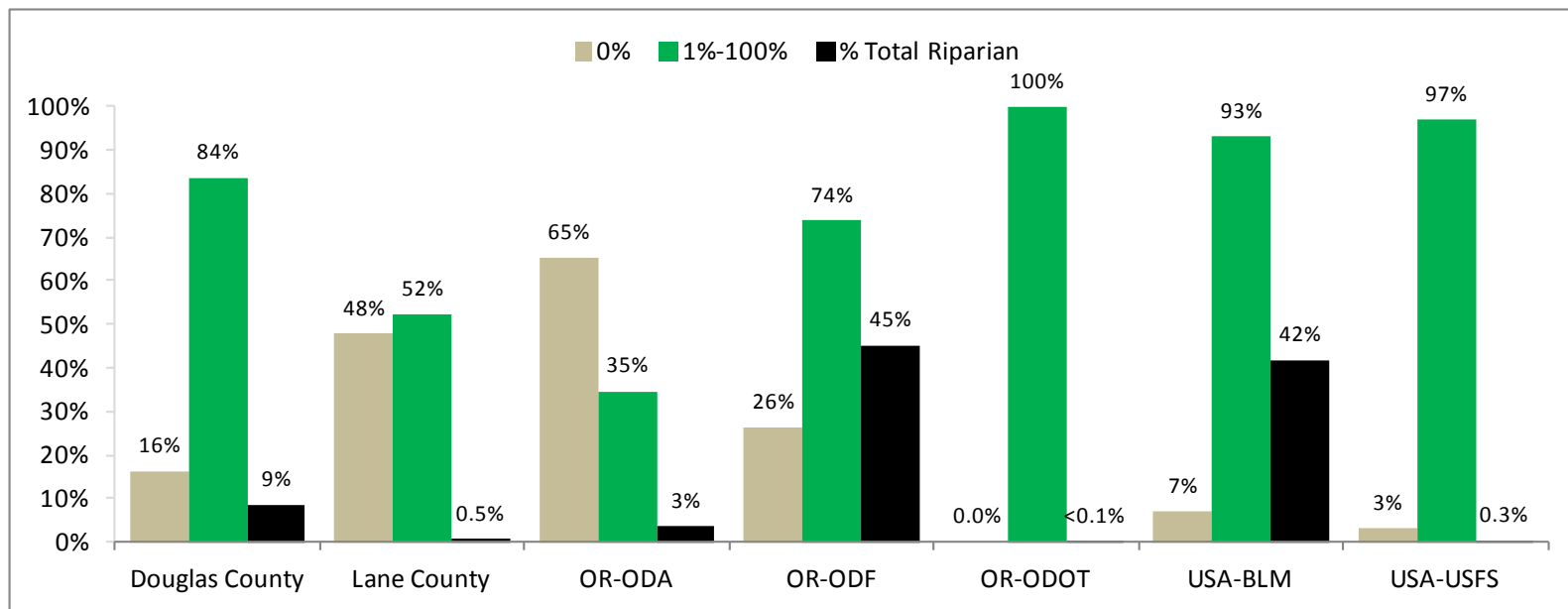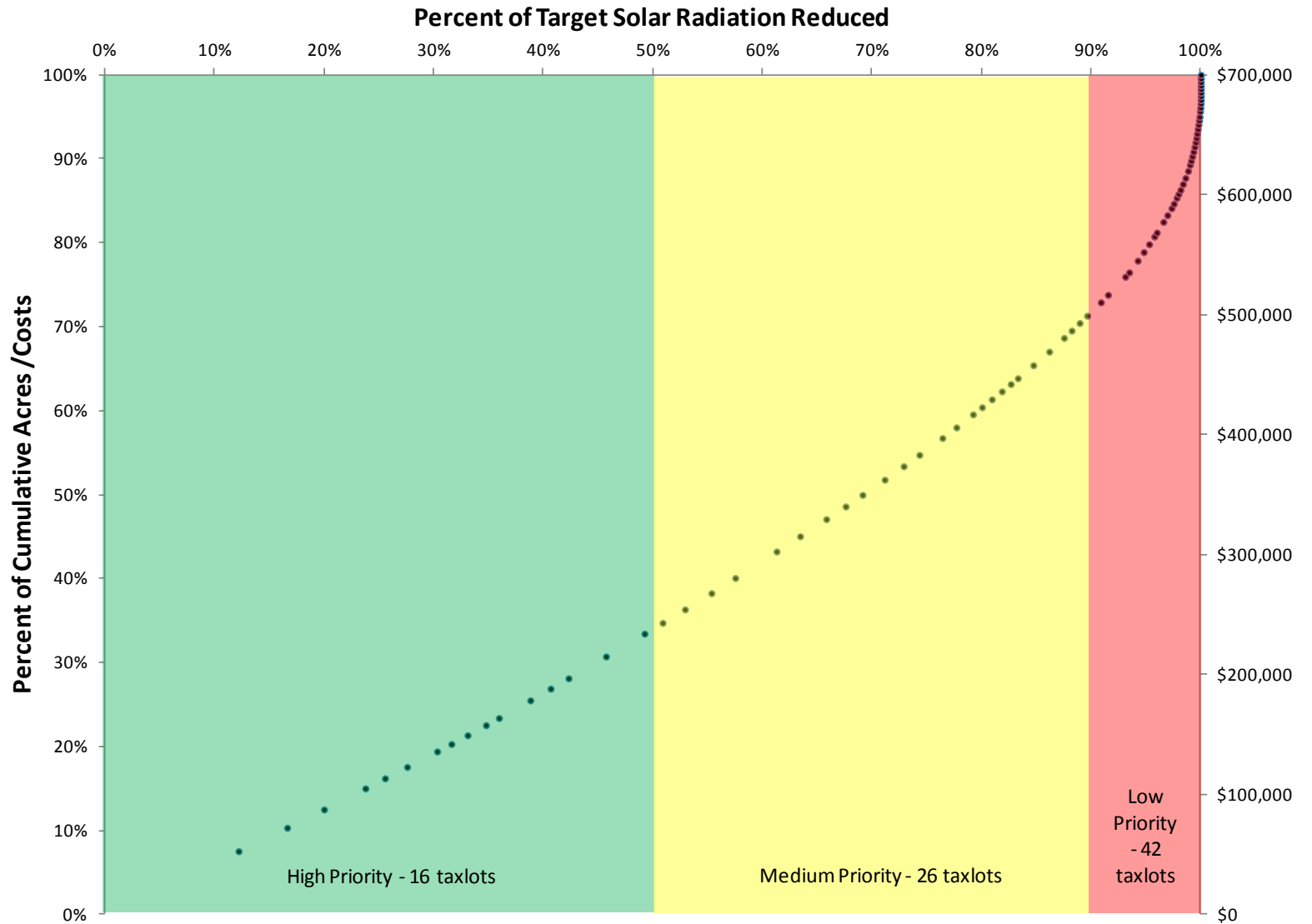| DMA	0%	1%-100%
Douglas County	420	2,161
Lane County	77	84
OR-ODA	690	366
OR-ODF	3,584	10,083
OR-ODOT		3
USA-BLM	871	11,788
USA-USFS	3	97

Y-axis: Acres (Log Scale)
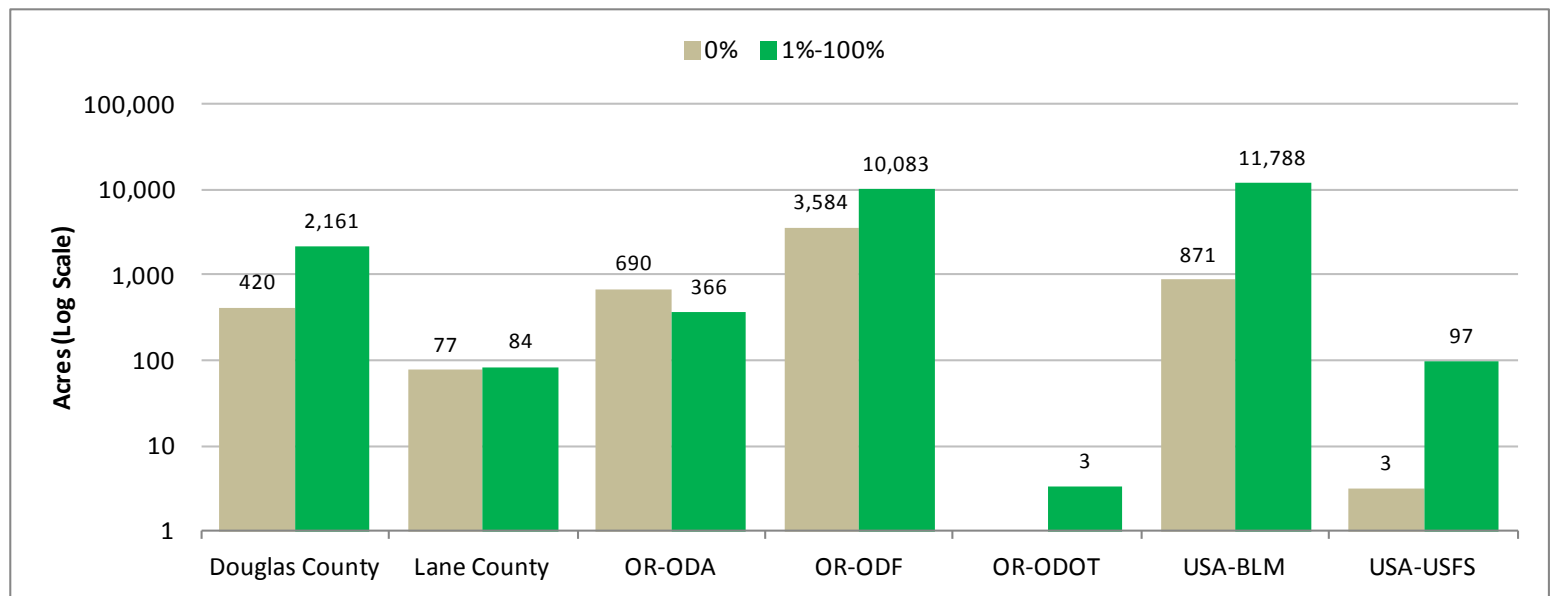
Percent area in each NLCD vegetation canopy classification within 30 meters of the stream for each DMA in the Upper Siuslaw River watershed

Legend: 0% ■ 1%-100% ■ % Total Riparian

DMA	0%	1%-100%	% Total Riparian
Douglas County	16%	84%	9%
Lane County	48%	52%	0.5%
OR-ODA	65%	35%	3%
OR-ODF	26%	74%	45%
OR-ODOT	0.0%	100%	<0.1%
USA-BLM	7%	93%	42%
USA-USFS	3%	97%	0.3%

Percent of Target Solar Radiation Reduced

High Priority - 16 taxlots

Medium Priority - 26 taxlots

Low Priority - 42 taxlots

EPA-6822_000054

Protecting Cold Water Criterion

- WA temp standard
- CA temp/shade standard
- OR/WA/CA BMPs on Type-F or equivalent (figures)
- Note that this has been vetted with CA & WA

Western Oregon Fish-Bearing Streams

EPA-6822_000056
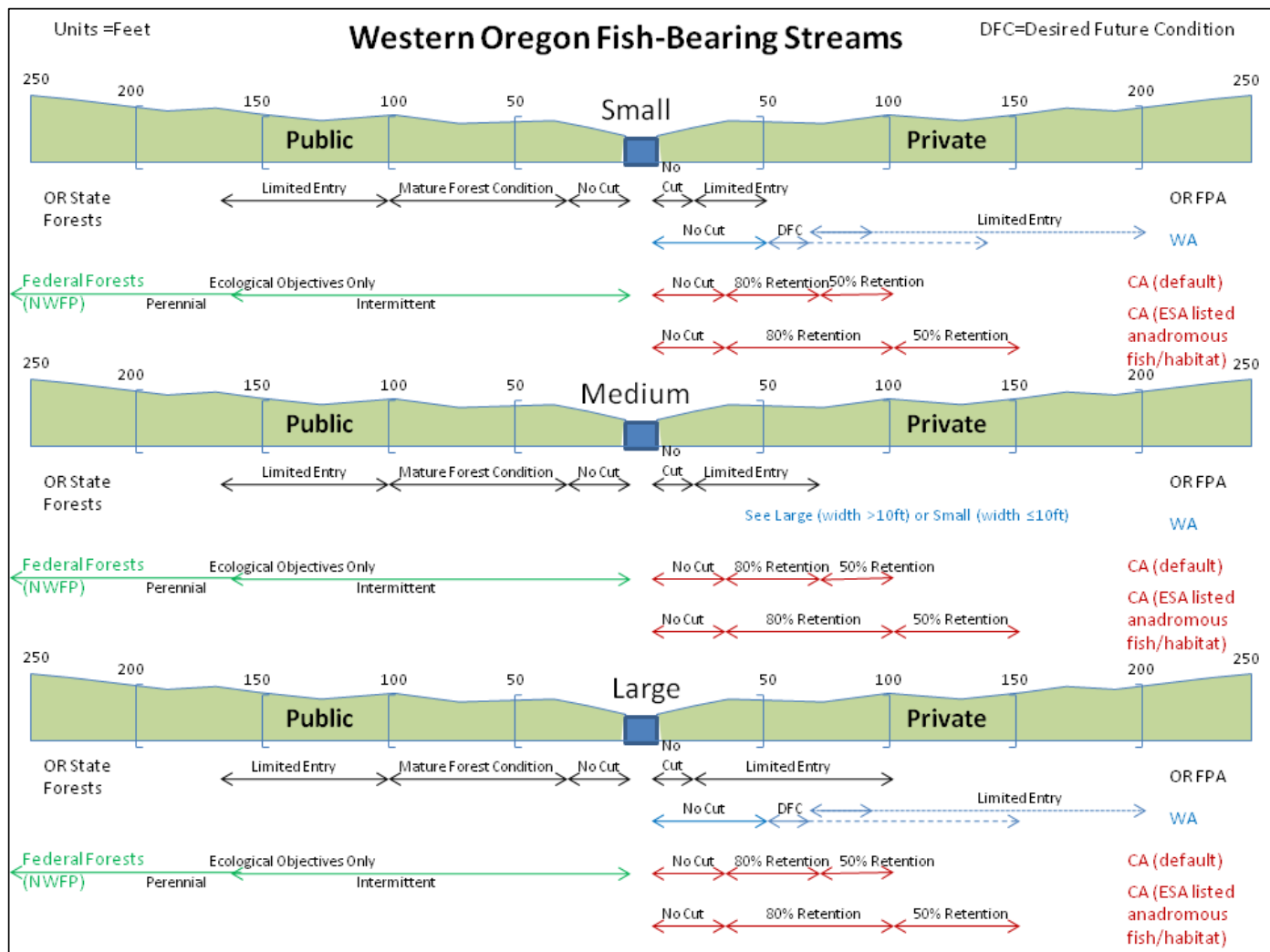
Questions?

Oregon Temperature WQS
(OAR 340-041-0028)(2)

Commission's Policy is:

• Protect aquatic ecosystems from adverse warming and cooling caused by anthropogenic activities;

• Minimize the risk to cold-water aquatic ecosystems from anthropogenic warming;

• Encourage the restoration and protection of critical aquatic habitat;

• Control extremes in temperature fluctuations due to anthropogenic activities;

• Minimize additional warming due to anthropogenic sources

EPA-6822_000058

Protecting Cold Water Criterion
(OAR 340-041-0028(11))

• PCW limits temperature increases to 0.3^{o}C in waterbodies colder than the numeric criteria, measured for all sources combined at the point of maximum impact where salmon, steelhead or bull trout are present [OAR ...(11)(a)].

- Natural thermal regime provides best conditions for fish.*
- Value in diversity of temperatures, including colder than BBNC.*
- Prevent accumulation of heat in fish-bearing reaches.*
- Retain assimilative capacity for climate variation & climate change.

• Point sources must also limit warming in spawning reaches [OAR ...(11)(b)].

• Some waterbodies may also be covered by a temperature TMDL. Meeting TMDL allocations should ensure PCW compliance.

*From Summary of 2003 TAC findings.

EPA-6822_000059